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Cross-Sectional Analysis of Household Food Demand in Estuaire Gabon: A Near-Ideal Quadratic Demand System Approach

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Abstract: Gabon depends heavily on food imports to safeguard its food security; yet household food consumption patterns remain underexplored. This study investigates the structure of food demand in the Estuaire region, incorporating demographic determinants such as the age of the household head, household size, youth proportion, and residential distance from shopping centers. Using primary data collected from a randomized survey of 410 households, the analysis employs the Quadratic Almost Ideal Demand System (QUAIDS) model to estimate expenditure and price elasticities. The results indicate that expenditure elasticities are universally positive, with luxury items, including meat, eggs, and fish, exhibiting greater sensitivity compared to staple foods such as poultry, oil, rice, cassava, and bananas, which display inelastic demand. Price elasticities for meat, poultry, fish, eggs, and rice are negative, adhering to the law of demand. Demographic factors, including education, age, and residential location, significantly influence the consumption of meat, cassava, bananas, and oil. Household size, employment type, and youth composition also emerge as critical determinants of increased demand for poultry, fish, and rice. These findings offer policy-relevant insights to strengthen food security and address socioeconomic disparities.

Keywords: food demand system; non-parametric; elasticity; QUAIDS; Estuaire; Gabon

Academic Editor: Steliana Rodino

Received: 26 December 2024
Revised: 24 January 2025
Accepted: 24 January 2025
Published: 26 January 2025

Citation: Ignanga, C.; Chen, Y.; Zhao, Y.; Liu, H.; Yu, W. Cross-Sectional Analysis of Household Food Demand in Estuaire Gabon: A Near-Ideal Quadratic Demand System Approach. *Agriculture* **2025**, *15*, 268. https://doi.org/10.3390/agriculture15030268

1. Introduction

Globally, demographic shifts, urbanization, income growth, and lifestyle changes have profoundly influenced food consumption patterns and the composition of household food baskets, with significant implications for national food security [1–4]. Rising incomes and urbanization are particularly associated with a dietary transition, characterized by a shift from staple cereals to higher-value foods such as fish, meat, dairy products, and fruits [4–7]. While these trends are global, Gabon is no exception. Food, as one of the most fundamental human needs, encompasses two critical dimensions: supply and demand [8]. Gabon is distinct among African countries along the Atlantic seaboard due to

its unique characteristics, including a small population, substantial oil wealth, diverse fishery resources, and a longstanding forestry tradition.

However, Gabon's reliance on oil revenues has led to recurrent budget crises driven by fluctuations in oil prices and exchange rates, contributing to a high level of national debt (African Coastal States). Despite its natural resource wealth, the agricultural sector remains marginal in economic significance [9]. The country is heavily dependent on food imports, with approximately 80% of national food needs met through imports from Europe and other regions [10,11]. This dependency has exacerbated food and nutritional insecurity, making it a pressing national challenge.

Several studies have explored food consumption in Gabon. For instance, ref. [12] conducted a cross-cultural analysis highlighting the prevalence of insect consumption. Ref. [13] emphasized the need to address food and nutritional security in protected areas, identifying frequent undernutrition, particularly among children and the elderly, through weighing methods. Ref. [14] found that bushmeat serves as a primary protein source in rural villages, with consumption influenced by income, distance, and the education level of household heads. Other studies have investigated consumption patterns and resource use. Refs. [15,16] analyzed out-of-home eating habits and consumer demand for bushmeat, respectively. Research by [17–20] examined the role of natural resource-based foods in population food security and nutrition, applying methods such as heuristic simulation, household diversity analysis, and chi-square testing.

Despite existing studies on food consumption, security, and nutrition in Gabon, there remains a gap in understanding the specific impact of demographic and socio-economic factors—such as the age of the household head, household size, the proportion of youth, and the distance from the household to shopping centers—on food consumption patterns in the Estuaire province. Additionally, studies based on the QUAIDS (Quadratic Almost Ideal Demand System) model to assess the influence of these factors on household food preferences are still limited. This gap raises important questions about the underlying mechanisms of food consumption and nutritional security in Gabon, particularly in the capital, highlighting the need for more focused research to inform targeted food policies.

This study proposes an in-depth examination of food consumption behavior in the Gabon Estuary, by analyzing household responses to income-related variations in food prices, thus providing a comprehensive understanding of food choices. Moreover, balanced food consumption in a household stem from price decreases closely linked to competition in favor of local economic growth driven by the significant consumption of cheap local produce. Balanced food consumption thus increases household purchasing power. Estuaire is one of the provinces with the highest food consumption, accounting for half of the national population, representing 49.5% of the total population [21,22].

In addition, several initiatives aimed at strengthening the understanding of food demand and consumption patterns in Gabon had already been implemented, such as the United Nations Food Production and Resilience Project [23], the seed program initiated in 2014 to support small-scale producers in rural areas [24] and the creation of high-productivity agricultural zones (ZAP), initiated by the government to achieve economies of scale in logistics and technical assistance, while optimizing land management. Gabon has also established partnerships with local development organizations such as the African Development Bank (ADB) and the Bank of Central African States (BEAC) to develop sectors such as rice, chicken and pork. Despite these government initiatives aimed not only at improving the knowledge of food demand and consumption patterns, but also at strengthening food security and community resilience, Gabon remains a major importer of these products, and its agricultural sector continues to decline. Furthermore, the innovation of this research lies in the application of an advanced econometric model in a little-explored context, using specific primary data to examine unique food consumption

dynamics. This will further provide important information to policy makers and researchers with a view to continually improving the literature on household food preferences and the role of socio-demographic variables in shaping consumption patterns. The study will also address the concern of how households rank staple and luxury foods, taking into account habits, expenditures, and demographic factors that influence household food choices.

The organization of this article is as follows. Section 1 provides the introduction. Section 2 describes materials and methods. Section 3 present the results and discussions. In Section 4 we outline the conclusion and policy implications.

2. Materials and Methods

2.1. Study Area

Estuaire, the province that hosts Gabon's capital, covers an area of 20,740 km² and is the most populous region in the country, with a population of 933,162 in 2018, representing nearly half of Gabon's total population [25]. The province is characterized by its cosmopolitan nature, with residents from various regions of the country. The study was conducted throughout the Estuaire region (Figure 1) due to its significant role in national food consumption patterns. According to demographic projections, Gabon's population is expected to reach 2,469,296 by 2025, with an urban majority (87.6%). The Estuaire region is projected to continue accounting for approximately half of the country's total population [21] and will represent 98% of the urban population.

The selection of Estuaire for this study is motivated by its large population and the diversity of household dietary patterns. Moreover, Gabon has become increasingly dependent on food imports to meet domestic consumption needs, and this dependence on food imports is reflected in soaring food prices, particularly in the Estuaire province. Moreover, agricultural production in Gabon has fallen from 15% in the 1960s to around 4.4% in the recent past [26]. Currently, expenditure on food imports exceeds XAF 469,851,213 per year [27], placing the country at a critical juncture that could lead to serious food security problems in the event of a global food crisis.

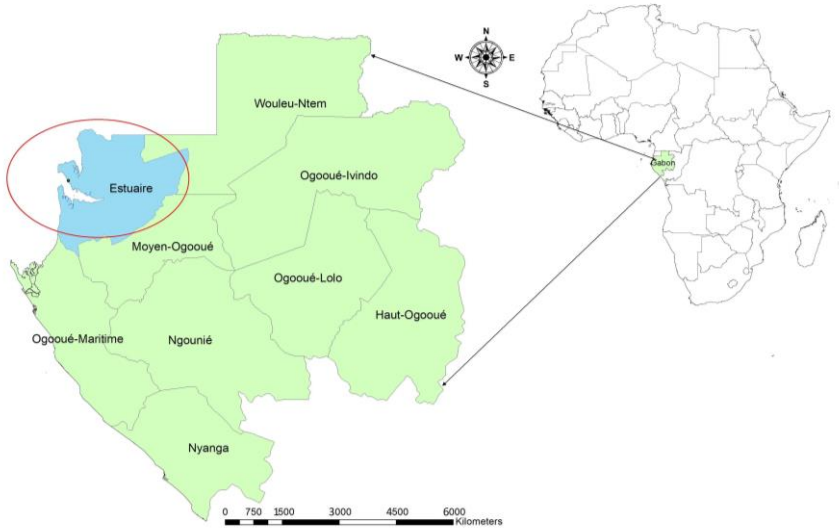

Figure 1. Location of the province of Estuaire, the site of the study.

2.2. Food Demand Data

The data for this study come from the household survey conducted between 25 January and 15 March 2024 in the Estuaire province of Gabon as part of this research project. The dataset includes information on the quantities of major commodities, food prices, and various household socioeconomic and demographic characteristics. The analysis focuses on household consumption patterns, food prices, and total expenditure on different products, as well as social and economic demographic indices. The data collected were subjected to descriptive statistical analysis and the application of the QUAIDS model using the Stata 16 software.

Simple random sampling was adopted for its flexibility and to obtain a representative sample. In total, we surveyed 410 households, giving us a 5% confidence interval in favor of our research. The sample size for this research was determined according to [28] on the basis of the following formula:

$$n = \frac{N}{1+N.\delta^2} \quad (1)$$

where

n represents sample size;

N represents population size;

δ represents the desired margin of error expressed in decimal places. The respondents were mainly heads of households. The field survey was conducted using two approaches: discussions with heads of households and personal observations. Product groups were classified by the authors based on their experience and nutritional and economic criteria. Following the approach outlined by [29], product similarity was determined from two perspectives: nutritionists typically classify foods based on nutrient content, while economists consider factors such as complementarity between foods and their marketing characteristics.

For this analysis, eight aggregate product groups were selected: meat, poultry, fish, eggs, oil, rice, cassava, and bananas. A ninth category, "other foods," was also included. This classification system reduces the number of parameters in the model, thereby facilitating the estimation of the demand system. The value of each food item was determined by calculating a weighted average of the prices for specific items reported by the households. The prices of food product groups vary due to differences in the types of products consumed within each group and price fluctuations affecting each food category. These variations are influenced by factors such as product quality disparities, seasonal changes, and international market conditions. In the estimation process, demographic factors related to the household were incorporated, including the education level of the household head, the age of the head of the household, household size, residential distance to shopping centers, the occupation of the head of household, and the percentage of young people in the household.

2.3. Description of Associated Demographic Variables

Descriptions of the demographic variables used in the analysis are presented in Table 1. According to relevant studies on factors influencing household food consumption as a function of survey sample size, there are several variables. In fact, we count a total of six in our particular case. In countries like ours, this reduced number of targeted variables makes it easier to pinpoint the subject, as it optimizes our research by providing clear results whose interpretation is trivial and better adapted to our realities. In addition, these sociodemographic and economic variables better characterize the behavior of our households. On average, households consisted of four individuals, with monthly food expenditures amounting to approximately 92 USD. Age played a significant role in food preferences. Households with individuals over 44 years of age primarily consumed plant-based

products, while younger individuals, particularly in lower-income households, favored animal proteins. Lower and middle education levels were found to positively influence the consumption of poultry, oils, vegetables, and rice. Households engaged in agriculture showed a higher preference for poultry, vegetables, cassava, and bananas, while those involved in other income-generating activities preferred pork, beef, fish, fruit, and rice. Distance from the household to the food shopping center also had an impact on consumption patterns. For households located more than 5 km from shopping centers, the consumption of cassava and milk increased, while the consumption of other protein sources declined. This trend may be attributed to the presence of agricultural activities in more remote areas and the pricing of different types of milk. Households with a higher proportion of young people exhibited a greater food burden, with an increased consumption of poultry, fish, vegetables, and rice. These preferences are likely influenced by the larger household size and food prices reported by households.

Table 1. Description of demographic variables associated with different food items.

Item	Group	No. of obs	Proportion	Pork	Beef	Mutton	Poul	Fish	Milk	Egg	Oil	fruit	Veg	Rice	Cassava	Banana
				Average share of food consumption												
Age	Young (<44)	236	58	0.31	0.34	0.13	2.32	1.21	0.55	0.30	1.02	0.40	1.13	3.73	0.96	0.65
	Oldest (≥44)	174	42	0.31	0.20	0.06	1.97	0.94	0.33	0.21	0.90	0.21	1.42	2.68	1.38	0.80
Education	Lower level (1)	72	18	0.22	0.10	0.03	2.33	0.96	0.35	0.25	1.01	0.23	2.10	2.97	1.45	0.91
	Middle (2)	142	35	0.22	0.16	0.08	2.28	1.00	0.41	0.19	0.96	0.21	1.16	3.25	1.19	0.66
	High level (3)	196	47	0.41	0.43	0.14	2.03	1.22	0.53	0.32	0.96	0.43	1.01	3.42	0.99	0.68
Occupation	Famer (=0)	72	18	0.26	0.13	0.12	2.32	0.84	0.35	0.29	1.13	0.16	2.65	2.23	2.35	1.38
	Others (=1)	338	82	0.32	0.31	0.10	2.14	1.15	0.48	0.25	0.94	0.36	0.96	3.51	0.88	0.57
Distance	≤5 km	195	48	0.30	0.29	0.10	2.25	1.14	0.44	0.27	0.99	0.33	1.31	3.72	0.83	0.72
	>5 km	215	52	0.32	0.27	0.10	2.09	1.06	0.48	0.25	0.95	0.31	1.21	2.88	1.43	0.71
Size	>4	172	42	0.24	0.19	0.79	1.95	0.98	0.39	0.15	0.78	0.21	0.74	2.86	0.79	0.54
	≤4	238	58	0.36	0.34	0.11	2.33	1.18	0.51	0.34	1.11	0.40	1.63	3.58	1.39	0.84
Younger rate	≤0.30	176	43	0.39	0.33	0.14	2.54	1.24	0.49	0.35	1.18	0.38	1.66	3.74	1.42	0.88
	>0.30	234	57	0.20	0.24	0.68	1.89	0.99	0.44	0.19	0.81	0.27	0.95	2.93	0.93	0.59

2.4. Support Request Model

The Linear Approximate Almost Ideal Demand System (LA/AIDS) is a widely used framework for analyzing the effects of price and income changes when household expenditure or budget data are available [30]. The AIDS model aligns well with the principles of consumer choice, does not assume additive preferences, and, in some cases, allows for a consistent integration of individual needs with market demands. To illustrate this, we begin by presenting the functional structure of the Engel curve, as shown in Figure 2.

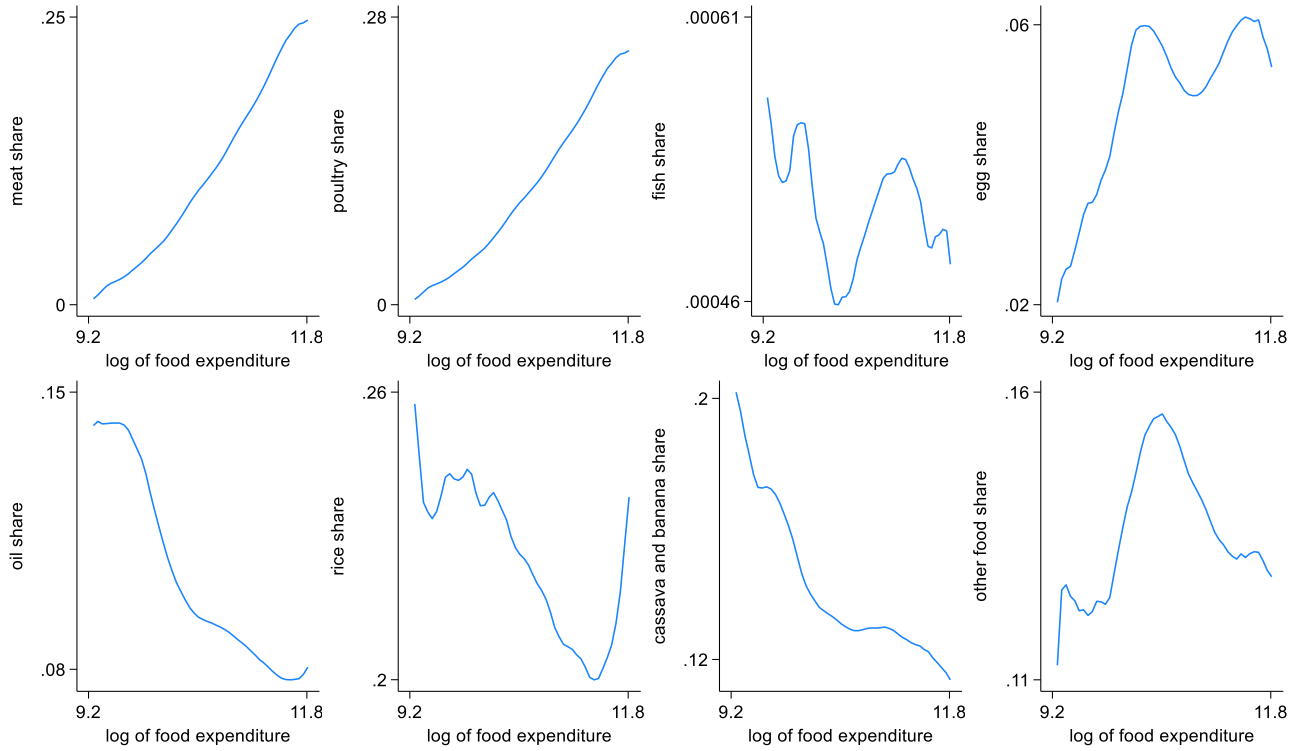

Figure 2. Non-parametric Engel curves for food groups.

To identify functional structures, it is necessary to analyze the equations for the distribution of household expenditures [31]. It is convenient to use nonparametric regression to evaluate the first form of this function. In this model, the expenditures for each share were calculated using the log of total expenditures. It is important to maintain compositional homogeneity using nonparametric regression, resulting in strong reasons to believe that the shape of Engel curves can vary depending on labor market status and region [32–34]. In principle, nonparametric regression aims to calculate the regression function, ~ (uy) = E(y/x), by estimating the location of y in a given band of x. In this analysis, y is the proportion of the food group, and x is the log of living expenses per household. This estimation method is used to analyze the structure of Engel curves before turning to the analysis of demand systems using other covariate variables. The objective is to use Epanechnikov's weighting function $K(u)= 3/4(1 - u^2)$ by applying the formula u = ln(x) to elaborate a grid of 50 equidistant points over the given interval, $[u_0, u_1]$ [35]. Each x-point is followed by a weighted linear regression of the food group's share on the log household living expenditure [29].

The nonparametric estimates for the eight food groups are presented in Figure 2. The Engel curves exhibit shapes consistent with theoretical expectations. Notably, the budget shares do not follow a clear linear pattern, suggesting that spending is not linearly related to budget shares. This observation implies that the commonly used Linear Approximate

Almost Ideal Demand System (LA/AIDS) may not adequately capture current household consumption behavior. Therefore, we adopt the Quadratic Almost Ideal Demand System (QUAIDS) model, as proposed by [36], to define a demand system that incorporates demographic variables. To analyze the household budget share behavior in Gabon Estuaire, the QUAIDS model, a quadratic extension of the Almost Ideal Demand System (AIDS) [30], was applied. The advantage of this model lies in its quasi-linearity, which allows for a flexible representation of consumption behaviors, particularly the quadratic form of the Engel curves. The demand function for QUAIDS in this study is specified as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{ln\left[\frac{m}{a(p)}\right]\right\}^2 + \sum \rho_i \mathrm{L} + \mu_\mathrm{i} \quad (2)$$

with

$$lna(p) = \alpha_i + \sum_j \alpha_j lnp_j + \frac{1}{2}\sum_j \sum_j \gamma_{ij} lnp_i lnp_j \quad (3)$$

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad (4)$$

where w_i is the budget share of good *i*, and the price of good *i* is represented by p_i while $a(p)$ and $b(p)$ are functions of the price vector p, and *m* represents the total income of the household. The indirect utility function from which Equation (1) is derived requires that $a(p)$ be homogeneous from degree 1 to p and $b(p)$ homogeneous from degree 0 to p. The term $\rho_i \mathrm{L}$ represents the set of social and demographic variables and μ_i is the regression error term. Equation (4) shows compliance with the limitations of the model.

$$\sum \alpha_i = 1, \sum_i \beta_i = 0, \sum_j \gamma_{ij} = 0, \gamma_{ij} = \gamma_{ji} \quad (5)$$

According to [36], the formulas for elasticities in QUAIDS are provided. These results are obtained by first distinguishing Equation (3) of *lnm* and *lnpj*, respectively, in order to obtain the following:

$$\varepsilon_\mathrm{i} = \frac{\partial w_i}{\partial lnm} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{ln\left[\frac{m}{a(p)}\right]\right\} \quad (6)$$

$$\eta_\mathrm{ij} = \frac{\partial w_i}{\partial lnm} = \gamma_{ij} - \mu_\mathrm{i}\left(\alpha_j + \sum_k \gamma_{jk} lnp_k - \frac{\lambda_i \beta_j}{b(p)}\left\{ln\left[\frac{m}{a(p)}\right]\right\}^2\right) \quad (7)$$

$$\mathrm{e_{ij}} = \eta_\mathrm{ij} + \varepsilon_\mathrm{i} * w_{ij\,(8)}$$

Equation (5) is the elasticity of the expenditure of the food groups. The two equations ((6) and (7)) are the uncompensated (Marshallian) price elasticities (proper and cross-price elasticities) and the compensated (Hicksian) price elasticities, respectively.

3. Results and Discussion

3.1. QUAIDS Model Parameters

Table 2 presents the descriptive statistics for the budget shares of food groups and their corresponding prices. It also provides the means and standard deviations (SDs) of the variables across different food products. The results indicate that the average food expenditure shares for the various products range from 0.048 to 0.210, reflecting moderate expenditure levels. In contrast, the average prices of the food groups range from XAF 931.67 to XAF 3514.31 revealing substantial price variability. The standard deviations of food expenditure shares range from 0.039 to 0.136, suggesting a moderate level of

homogeneity in consumption patterns. However, the price variables exhibit higher standard deviations, from 180.23 to 535.28, indicating greater dispersion in price levels across the food products.

Table 2. Summary statistics on food demand.

Commodity Groups	Variable	Obs.	Mean	Std. Dev.
Pork, beef, and mutton	w1	410	0.116	0.136
Poultry	w2	410	0.210	0.117
Fish	w3	410	0.154	0.110
Eggs	w4	410	0.048	0.060
Oil	w5	410	0.085	0.039
Rice	w6	410	0.193	0.105
Cassava and banana	w7	410	0.128	0.124
Other foods	w8	410	0.130	0.094
	Unit price (FCFA per kg)			
Pork, beef and mutton	p1	410	3163.86	535.28
Poultry	p2	410	1392.20	180.23
Fish	p3	410	2264.90	528.18
Eggs	p4	410	3514.31	238.50
Oil	p5	410	1340.12	535.28
Rice	p6	410	931.67	498.07
Cassava and banana	p7	410	1131.42	454.94
Other foods	p8	410	1132.48	423.88

3.2. The Elasticity of Expenditure, Own Price, and Cross-Price

It can be seen in Table 3, that the elasticities of expenditure for all food groups are positive and indicate values greater than one, called elastic demand; values less than one are called inelastic demand. The results indicate not only that all food groups are normal goods (goods whose consumption increases with income) but also that consumers tend to spend in different proportions on each type of food as income increases. Two groups of foods are very elastic, the consumption of meat and eggs, which means that a 1% increase in price will lead to a 2.4% and 1.8% decrease in the quantity demanded, respectively. Then, two other food groups have a slightly elastic demand; these are fish and other foods. An increase of 1% in the price of the products will lead to a decrease of 1.09% and 1.46% in the quantities requested, respectively. Finally, basic foods such as poultry, oil, rice, cassava, and bananas have an inelastic demand. They revealed that a 1% increase in price will result in a slight decrease of only 0.38, 0.56, 0.84, and 0.31 in the quantities demanded, respectively. A comparative analysis of our results with those of other research reveals that [37] report an estimated meat demand of 1.27 for Chinese rural households, while its rice elasticity (0.70) is considered an essential food, along with cassava and bananas [38], in line with our observations. Ref. [39] showed that the expenditure elasticity of eggs is very elastic at 1.7, which is consistent with this current study's observations. The analysis by [40] corroborates the same finding that spending on meat and fish is elastic (1016) and these are perceived as high-end items. Ref. [29] also highlighted similar findings, where meat, fish, eggs, and other foods have expenditure elasticities greater than one.

In this study, both uncompensated and compensated price elasticity of demand are used to capture the change in the quantity demanded of a product resulting from changes in its price. The price elasticities for food products consumed by residents of the Estuary province are estimated to be negative for meat, poultry, fish, eggs, and rice, ranging from −0.28 to −1.76. This negative relationship confirms the law of demand, indicating that demand decreases as prices increase [29]. Specifically, a 1% increase in the price of these

products leads to a decrease in demand by 0.57%, 1.76%, 0.77%, 1.16%, and 0.52%, respectively. Within the household food consumption structure, the price elasticity for poultry and eggs exceeds one in absolute value, signifying that households are more sensitive to price fluctuations for these two products. This suggests a higher degree of flexibility in consumption decisions for poultry and eggs, indicating a preference for these animal proteins. In contrast, the price elasticity for meat, fish, and rice is lower, suggesting that households are less sensitive to price changes for these products and exhibit more stability in their consumption patterns. Ref. [41] reports a price elasticity of rice demand in urban Beijing of −0.44, which aligns with the findings of this study. Their results indicate that urban households exhibit lower sensitivity to price changes, consistent with the observation that the price elasticity of rice in Estuaire is also less than one, indicating a relatively inelastic demand.

The price elasticity of demand for oil, cassava, and bananas is positive, indicating inelastic demand for these products. In other words, demand for these food items is not significantly affected by price fluctuations. A 1% increase in the price of oil, cassava, and bananas results in a slight increase in demand by 0.196% and 0.155%, respectively. This behavior is characteristic of commodities with inelastic demand, where an increase in price does not reduce demand. Rather, higher prices tend to increase the sales or turnover of these goods. Economic theory suggests that in such cases, demand moves in the same direction as price, leading to higher sales rather than a reduction in quantity demanded.

Most of the cross-price elasticities within the basic food structure of households are negative, suggesting that the primary food commodities are complementary. However, those with positive signs indicate competitive or substitution relationships, as noted in the study by [37]. For instance, an increase in poultry prices prompts households to increase their consumption of fish (0.2645), eggs (0.0203), and other foods. Similarly, a rise in rice prices encourages households to consume more cassava and bananas (0.1174). These findings can be explained by the shift from complementary to substitute food products as a result of price fluctuations. Furthermore, the difference between uncompensated and compensated elasticities highlights the importance of expenditure effects in guiding households' demand-side decisions.

Finally, regarding demographic parameters, the results show that household demand for meat, cassava, bananas, and oil is elastic with respect to education, age, and residential distance from shopping centers. As education, age, and residential distance from shopping centers increase by 1%, the share of food expenditure on these items increases. In contrast, the share of expenditure on poultry, rice, and other foods decreases. However, household size, the type of employment, and the percentage of young people in the household were found to contribute to a higher consumption of poultry, fish, rice, and other foods. Specifically, as the number of younger people in the household increases, and the overall household size grows, the consumption rate of poultry, rice, and other products significantly increases by 0.031%, 0.013%, and 0.039%, respectively, while the expenditure share for other food groups decreases. This contrasts with the findings of [42], who found that as household size increases, households tend to adjust their demand structure by favoring more affordable items like cereals, roots, and tubers, while reducing consumption of animal proteins, which are perceived as more expensive. Similar results were observed by [43] in North Central Nigeria, where the demand for root crops was positively influenced by the age of the head of the household and their occupation. The education of the household head also had a significant positive impact on all food groups [43]. Additionally, the findings of [44] underscore the importance of educational attainment in shaping dietary decisions. Similarly, ref. [40] found that in Kenya, household size has a statistically significant effect on food consumption expenditure.

Table 3. The elasticity of expenditure, Marshallian, Hicksian cross-price elasticity, self-price elasticity, and elasticities of social and demographic factors of the consumption structure of residents in the Gabon Estuaire.

	Meat	Poultry	Fish	Egg	Oil	Rice	Cassava_Banana	Other Foods
Expenditure	2.4417	0.381	1.085	1.8	0.5556	0.8421	0.3077	1.4615
Education	0.0232	−0.0147	0.0085	−0.001	0.0002	−0.0159	0.0117	−0.0101
Age	0.0086	−0.0577	0.0161	−0.0161	0.0328	−0.0709	0.1296	0.0084
Size	−0.0255	0.0308	−0.0013	−0.0119	0.0041	0.0131	0.0011	−0.0065
Distance	0.0038	−0.0099	0.001	0.0071	−0.0007	−0.0154	0.0137	0.0036
Occupation	0.0003	0.0107	0.035	−0.0117	−0.0049	0.0684	−0.1059	−0.0481
Younger Rate	−0.0375	−0.0126	0.0013	−0.0026	−0.0021	−0.006	0.0315	0.0392
				Uncompensated				
Red Meat	−0.5711	−1.0139	0.0676	0.0666	−0.3288	−0.3687	−0.6504	−0.5588
Poultry	−0.3321	−1.7554	0.2645	0.0203	0.0073	−0.0528	0.2182	0.3483
Fish	0.2034	−0.1655	−0.7703	−0.0677	−0.0866	−0.3089	−0.0058	−0.1284
Eggs	0.2369	−0.1231	−0.4139	−1.1552	−0.4143	0.0095	−0.6300	−0.8020
Oil	−0.2120	−0.0197	−0.0865	−0.1679	0.1961	−0.2238	0.2111	0.3151
Rice	−0.0409	−0.1552	−0.2766	0.0504	−0.1318	−0.5214	0.1174	−0.0939
Cassava_Banana	−0.3443	0.3678	0.1465	−0.1677	0.1685	0.2731	0.1547	1.0032
Other Foods	−0.3982	0.3358	−0.2728	−0.2915	0.1366	−0.2550	0.8532	−0.4951
				Compensated				
Red Meat	−0.2781	−0.5012	0.5559	0.1887	−0.1090	0.0952	−0.3330	−0.2414
Poultry	−0.2864	−1.6754	0.3407	0.0393	0.0416	0.0195	0.2677	0.3978
Fish	0.3336	0.0623	−0.5533	−0.0135	0.0111	−0.1028	0.1353	0.0127
Eggs	0.4529	0.2549	−0.0539	−1.0652	−0.2523	0.3515	−0.3960	−0.5680
Oil	−0.1453	0.0970	0.0246	−0.1402	0.2461	−0.1183	0.2833	0.3873
Rice	0.0602	0.0216	−0.1082	0.0925	−0.0560	−0.3614	0.2268	0.0155
Cassava_Banana	−0.3074	0.4324	0.2081	−0.1523	0.1961	0.3315	0.1947	1.0432
Other foods	−0.2228	0.6427	0.0195	−0.2185	0.2681	0.0227	1.0432	−0.3051

4. Conclusions and Implication

The findings of this study provide a clear pattern of household food demand that aligns with spending behaviors observed through a cross-sectional expenditure survey. Based on the nonparametric analysis of household expenditure models, the results suggest that Engel curves necessitate an extension of the AIDS model, incorporating quadratic terms in the log expenditure function. For this analysis, a comprehensive set of integrable quadratic log expenditure share systems was derived and applied to a pooled dataset of households in the Gabon Estuary.

The results from the QUAIDS model indicate that all food groups in the study area are normal goods, meaning their consumption increases with income. However, households tend to allocate their spending across different food types in varying proportions as income rises. Specifically, two food groups—meat and eggs—display highly elastic demand, while fish and other products exhibit slightly elastic demand. In contrast, basic foods such as poultry, oil, rice, cassava, and bananas show inelastic demand. Given these findings, it is crucial for the government to focus on the quality of essential foods and those with slightly elastic demand, rather than solely on the quantity, as this is where significant disparities between households are observed. Furthermore, negative price elasticities for meat, poultry, fish, eggs, and rice suggest that a reduction in the unit price of these proteins would likely lead to an increase in their demand.

In light of these findings, it is crucial that government authorities at all levels implement specific policies that encourage the production of key proteins in order to reduce

their prices and improve their access to households. On this basis, the study recommends the following:

- The effectiveness of government-initiated income policies in influencing consumption patterns due to higher expenditure elasticities than own-price elasticities;
- The establishment by the government of poultry breeding industries, for example, with a view to producing poultry on a massive scale at lower cost and in strict compliance with the regulations in force, not only to meet the considerable demand for basic animal proteins in our case, but also to promote the availability of raw materials at lower cost to small-scale producers;
- The promotion of agriculture by the government through greater support for grouping farmers into subsidized cooperatives in order to better meet demand for the essential foodstuffs in our case (oil, rice, cassava, and bananas), by increasing their supply and thus fostering price stability;
- The introduction of subsidized cooperatives for meat, egg, and fish producers by the government to meet demand for the elastic products in our case, and to stabilize consumer prices and encourage adequate supply in relation to demand.

Furthermore, the food products consumed in the Estuaire region primarily consist of basic necessities and luxury items. The inelastic demand for oil, cassava, and bananas suggests that price increases for these products will likely lead to higher sales for traders. The analysis of food demand also highlights a strong relationship between education, age, and residential distance from shopping centers, and the demand for meat, cassava, bananas, and oil. Specifically, as education, age, and residential distance from shopping centers increase, the share of food expenditure on these items grows. On the other hand, household size, the type of employment, and the percentage of young people in households have been found to influence the consumption of poultry, fish, rice, and other foods. Given the significant impact of household size and type of employment on food demand, the promotion of birth control and quality employment programs by government authorities could alleviate this food dependency. These initiatives could help to manage household size and improve the quality of employment, thereby alleviating household food demand.

We recognize that this study has certain limitations with regard to the use of cross-sectional data, and does not allow for the analysis of temporal evolutions. Furthermore, the study focuses solely on the Estuaire province, whereas differences may exist between urban and rural areas. It is therefore imperative that future research should focus on longitudinal analysis and extend the study to the whole country for a better understanding of disparities in Gabon's food consumption pattern.

Author Contributions: Conceptualization, C.I. and H.L.; Methodology, C.I., Y.C. and W.Y.; software, C.I. and W.Y.; validation, H.L. and Y.Z.; formal analysis, C.I., H.L. and Y.C.; investigation, C.I. and Y.C.; resources, H.L. and Y.Z.; data curation, C.I.; writing—original draft preparation, C.I.; writing—review and editing, C.I. and Y.C.; visualization, Y.C., Y.Z., C.I. and H.L.; supervision, H.L.; project administration, H.L.; and funding acquisition, Y.Z. All authors have read and agreed to the published version of the manuscript.

Funding: The National Social Science Fund Key Project (Grant No: 21AZD035), Science and Technology Innovation Project of Chinese Academy of Agricultural Sciences (Grant No:10-IAED-04-2025).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors acknowledge financial support from the National Natural Social Science Foundation of China (22CJL024).

Conflicts of Interest: The authors declare no conflicts of interest.

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